SUBSTITUTE FORM PTO-1390 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
12406-013001

U.S. APPLICATION NO. (If Known, see 37 CFR 1.5)
09/787400

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/SG 99/00073	9 July 1999 (09/07/99)	9 July 1999

TITLE OF INVENTION
ENCAPSULATION OF A DEVICE

APPLICANT(S) FOR DO/EO/US
Ewald Karl Michael Guenther

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☒ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 16 below concern other documents or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
    ☒ Return Postcard
    ☒ International Search Report
    ☐
    ☐
    ☐

CERTIFICATE OF MAILING BY EXPRESS MAIL
Express Mail Label No. EL 282 427 116 US
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U.S. APPLICATION NO. (IF KNOWN)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/787400	PCT/SG 99/00073	12406-013001

17. ☒ The following fees are submitted:

CALCULATIONS PTO USE ONLY

Basic National Fee (37 CFR 1.492(a)(1)- (5)):

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1000**

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$860**

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO..... **$710**

International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4)..... **$690**

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4)..... **$100**

ENTER APPROPRIATE BASIC FEE AMOUNT =	$860.00	
Surcharge of **$130** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$0.00	

Claims	Number Filed	Number Extra	Rate		
Total Claims	56 - 20 =	36	x **$18**	$648.00	
Independent Claims	2 - 3 =	0	x **$80**	$0.00	
MULTIPLE DEPENDENT CLAIMS(S) (if applicable)			+ **$270**	$720.00	
			TOTAL OF ABOVE CALCULATIONS =	$1580.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				$0.00	
			SUBTOTAL =	$1580.00	
Processing fee of **$130** for furnishing the English Translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f))				$0.00	
			TOTAL NATIONAL FEE =	$1580.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$0.00	
			TOTAL FEES ENCLOSED =	$1580.00	
			Amount to be refunded:		$
			Charged:		$

a. ☒ A check in the amount of $1580.00 to cover the above fees is enclosed.
b. ☐ Please charge my Deposit Account No. 06-1050 in the amount of $0.00 to cover the above fees. A duplicate copy of this sheet is enclosed.
c. ☒ The Commissioner is hereby authorized to charge any additional fees, which may be required, or credit any overpayment to Deposit Account No. 06-1050. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b) must be filed and granted to restore the application to pending status.

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OFFICIAL COMMUNICATION

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FOR THE PERSONAL ATTENTION OF:

BARBARA CAMPBELL

Number of pages including this page 4

Applicant : Ewald Karl Michael Guenther
Serial No. : 09/787,400
International Filing Date: July 9, 1999

Art Unit : Unknown
Examiner : Unknown

FACSIMILE COMMUNICATION

Title : Encapsulation Of A Device

Commissioner for Patents
Washington, D.C. 20231

Sir:

Attached to this facsimile communication cover sheet is a Preliminary Amendment, faxed this 10th day of March, 2002, to the United States Patent and Trademark Office.

Respectfully submitted,

Date: April 10, 2002

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#5/a

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Ewald Karl Michael Guenther
Serial No. : 09/787,400
International Filing Date: July 9, 1999
Title : ENCAPSULATION OF A DEVICE

Art Unit : Unknown
Examiner : Unknown

Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Prior to examination, please amend the application as follows:

In the claims:

Amend claims 20, 34, 37, 44 and 51 as follows:

20. The device of claim 1 wherein the cap support comprises a thickness greater than a height of the active component to form the cavity between the cover and the active component to prevent the cover from contacting the active component.

34. The method of claim 30 wherein the cap includes the cap support.

37. The method of claim 31 further compreses forming the cap support.

44. The method of claim 21 further comprises:
forming a first electrode layer over the substrate;
patterning the first electrode layer to form first electrodes of the OLED pixesl.

51. The method of claim 30 further compresise forming the cap support.

CERTIFICATE OF TRANSMISSION BY FACSIMILE

I hereby certify that this correspondence is being transmitted by facsimile to the Patent and Trademark Office on the date indicated below.

April 10, 2002
Date of Transmission

Signature

NiKia M. McNillion
Typed or Printed Name of Person Signing Certificate

REMARKS

The present preliminary amendment is submitted to convert the multiply dependent claims into normal claims.

Attached is a marked-up version of the changes being made by the current amendment.

Applicant asks that all claims be examined.

Respectfully submitted,

Date: 4/10/02

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Version with markings to show changes made

In the claims:

Claims 20, 34, 37, 44 and 51 have been amended as follows:

20. The device of claim 1 [, 2, 3, 6, 7, 8, 11, 13, 14, 16, 17, or 19] wherein the cap support comprises a thickness greater than a height of the active component to form the cavity between the cover and the active component to prevent the cover from contacting the active component.

34. The method of claim 30 [, 31, 32, or 33] wherein the cap includes the cap support.

37. The method of claim 31 [or 32] further compreses forming the cap support.

44. The method of claim 21 [or 32] further comprises:

forming a first electrode layer over the substrate;

patterning the first electrode layer to form first electrodes of the OLED pixels.

51. The method of claim 30 [or 33] further compresise forming the cap support.

ENCAPSULATION OF A DEVICE

Field of the Invention

The present invention relates to the fabrication of devices. More particularly, the invention relates to device encapsulation.

Background of the Invention

In device fabrication, one or more device layers are formed on a substrate. The layers are sequentially deposited and patterned to create features on the surface of the substrate. The layers can be patterned individually and/or as a combination of layers to form the desired features. The features serve as components that perform the desired functions, creating the device.

One type of device which is of particular interest is a light emitting diode (LED). LEDs can have a variety of applications. For example, a plurality of LED cells or pixels can be formed on a substrate to create a pixelated LED device for use as a display, such as a flat panel display (FPD).

Typically, an LED pixel comprises one or more functional layers sandwiched between two electrodes to form a functional stack. Charge carriers are injected

from both electrodes. These charge carriers recombine in the functional layer or layers, causing visible radiation to emit. Recently, significant advances have been made utilizing organic functional layers to form organic LEDs.

To protect the LED pixels from the environment such as moisture and/or air, the device is encapsulated with a package. Conventionally, LED packages comprises various kinds of cavity packages. The cavity packages typically comprise mounting a lid on the substrate. The cavity protects the organic LED pixels from being damaged by the package since they are very sensitive to pressure. Further, the cavity also enables the placement of desiccant material to cope with finite leakage rate of the device.

Flexible devices formed on thin or flexible substrates are being contemplated for new applications, such as flexible displays. However, conventional device packaging is not amenable to being flexible. This makes it difficult to satisfy the flexibility requirement of flexible devices, particularly those having relatively large surface areas such as displays.

As evidenced from the above discussion, it is desirable to provide an effective package for devices,

particularly those formed on thin or flexible substrates.

Summary of the Invention

The invention relates to encapsulating devices. The device includes active and non-active regions. Active components are provided in the active regions, separated by non-active regions. In one embodiment, a cap support on which a cap is mounted is provided. The cap support surrounds the periphery of the device and in at least one of the non-active regions. The cap support in the non-active regions are particularly useful for flexible devices since they provide support for the cap to prevent it from contacting the active components due to stress induced by bending.

Brief Description of the Drawings

Fig. 1 shows an embodiment of the invention;

Figs. 2a-e show a process for fabricating an electronic device in accordance with one embodiment of the invention;

Figs. 3a-b show a process for fabricating an electronic device in accordance with another embodiment of the invention; and

Figs. 4a-b show a process for fabricating an electronic device in accordance with one embodiment of the invention.

Preferred Embodiments of the Invention

The invention relates generally to the fabrication of devices. In particular, the invention provides a cost effective package for encapsulating devices, particularly those formed on flexible or thin substrates.

Fig. 1 shows a device 100 in accordance with one embodiment of the invention. The device can be, for example, an electrical, a mechanical, an electromechanical device, or a microelectromechanical system (MEMS). The device comprises one or more active components 110 formed on a substrate 101. In one embodiment, the active components are formed on active regions 115 of the substrate. Non-active regions 120 are provided on the substrate. As shown, the non-active regions separates the active components.

A cap support 130 is provided on the periphery of the device surrounding the active components. A cap 180 rests on the cap support. The cap hermetically seals the active components from the environment. The cap

support elevates the cap to prevent it from contacting the active components.

The cap support also provide support in non-active regions of the device. As shown, the cap support comprises support posts located in the non-active regions. Since the cap support is situated in the non-active regions, the functionality of the active components are unaffected. Locating support posts in the non-active regions provides additional support to the central portion of the cover layer. This prevents the cap from collapsing onto the active components due to stress. This is particularly useful for flexible devices.

In one embodiment, the device 100 comprises an electrical device. The electrical device comprises a pixelated organic LED device. Organic LED devices are described in, for example, United States Patent 4,720,432 and Burroughes et. al, Nature 347 (1990) 539, which are herein incorporated by reference for all purposes. Other types of electrical devices which are formed on a substrate, such as semiconductor lasers, are also useful.

The active components 110 include organic LED pixels. An organic LED pixel comprises at least one

organic layer 114 between first and second electrodes 112 and 116. The pixels are, for example, configured in an array to form a display, such as an FPD. FPDs are used in various consumer electronic products, including cellular phones, cellular smart phones, personal organizers, pagers, advertising panel, touch screen displays, teleconferencing equipment, multimedia equipment, virtual reality products, and display kiosks.

The pixels 110 are located on the active regions 115 of the substrate 101 and are separated by the non-active regions 120. Support posts 130 are located in the non-active regions of the substrate and in the periphery of the device surrounding the LED pixels. The support posts can be provided in one, some, or all the non-active regions. A cap 180 is mounted on the support posts to encapsulate the device in order to protect the pixels from air and/or moisture. Pads 190 coupled to the LED pixels can be provided. The pads enable external connections to the device.

The cap support serves to prevent the cap from contacting the LED pixels. The LED pixels can be damaged if the cap comes into contact with the LED pixels. In one embodiment, the height of the cap support creates a gap or cavity 118 between the surface

of the LED pixels and cap. The gap should be sufficient to prevent the cap from contacting the LED pixels. Typically, the gap is about 1-10 um in height. Of course, the gap height can vary due to the amount of stress induced (e.g., amount of bending required from the device, thickness of the cover layer, and lateral distance between support posts).

Figs. 2a-f show a process for fabricating a device in accordance with one embodiment of the invention. The device comprises, for example, an organic LED. Referring to Fig. 2a, a substrate 101 is provided on which the active components of the device are formed. The substrate can comprise various types of materials, such as glass or a polymer for supporting the active components. Other materials which adequately support the active components, such as ceramic or silicon, can also be used. Various types of semiconductor wafers are also useful.

In one embodiment, a flexible substrate is provided for fabricating a flexible device. The flexible substrate comprises a flexible material such as a plastic film. Various commercially available plastic films are useful. Such films, for example, include transparent poly(ethylene terephthalate) (PET),

poly(butylene terephthalate) (PBT), poly(enthylene naphthalate) (PEN), Polycarbonate (PC), polyimides (PI), polysulfones (PSO), and poly(*p*-phenylene ether sulfone) (PES). Other films such as polyethylene (PE), polypropylene (PP), poly(vinyl chloride) (PVC), polystyrene (PS) and poly(methyl methyleacrylate) (PMMA), can also be used.

In one embodiment, the flexible substrate should be thin to result in a thin device while providing sufficient mechanical integrity during the fabrication process to support the active components. Preferably, the flexible substrate should be as thin as possible while providing sufficient mechanical integrity during the fabrication process. In one embodiment, the flexible substrate is about 20 - 200 um thick.

In an alternative embodiment, the flexible substrate comprises glass. Thin semiconductor substrates or other thin flexible substrates can also be useful. In one embodiment, the thickness of the substrate is about 30 - 300 um.

In another embodiment, temporary support layers can be provided. The temporary support layers, for example, can be formed on the backside of the substrate to provide the support necessary during the fabrication

process. The package can be used to provide additional support to stabilize the substrate at the final product stage, enabling the temporary layer to be removed. Temporary support layers allow the use of thinner substrates, resulting in thinner devices.

Active and/or non-active regions are defined on the substrate surface. The active regions provide areas on the substrate on which active components are formed. Various techniques can be used to define the active and/or non-active regions. For example, photolithographic techniques can be used to define the active and/or non-active regions.

In one embodiment, the active components comprise organic LED pixels. The organic LED pixels are arranged to form a pixelated device. A pixelated organic LED device includes, for example, a plurality of first electrode strips formed on the substrate. The strips are arranged in a first direction. One of more organic layers are formed on the first electrodes strips. A plurality of second electrode strips is formed over the organic layers in a second direction. Typically, the first and second electrode strips are orthogonal to each other. The intersections of the first and second electrode strips form LED pixels. In one embodiment,

the non-active regions are represented by the areas which, when viewing the substrate from the top, exclude electrode materials. Alternatively, regions in which the electrodes do not intersect can be considered non-active regions.

Referring to Fig. 2b, the process of defining the active and/or non-active regions commences. In one embodiment, a device layer 112 is formed on the substrate. The device layer comprises, for example, a conductive layer. Other types of device layers are also useful, depending on the type of active components. The thickness of the device layer, for example, is about 0.1 - 1 um. The thickness, of course, can be varied according to design requirements.

In one embodiment, the device layer comprises a transparent conductive layer that serves as anodes for the LED pixels. The transparent conductive layer comprises, for example, indium-tin-oxide (ITO). Other types of transparent conductive layers such as zinc-oxide and indium-zinc-oxide are also useful. Various techniques, such as chemical vapor deposition (CVD) physical vapor deposition (PVD), and plasma enhanced CVD (PECVD), can be employed to form the device layer. The conductive layer should be thin to reduce optical

absorption and negative impact on subsequent film formation while satisfying electrical requirements. In one embodiment, the conductive layer comprises a thickness of about 100 nm.

After the device layer is formed, it is patterned to define the active and/or non-active regions. Conventional techniques, such as photolithography and etching, can be used to pattern the device layer. Patterning techniques using a stamp are also useful. Such techniques are described in concurrently filed international patent application titled "Mechanical Patterning of a Device Layer" (attorney docket number 99E 8062), which is herein incorporated by reference for all purposes. The active regions comprise, for example, the portions of the device layer remaining on the substrate surface and the non-active regions comprise portions of the exposed substrate surface.

In one embodiment, the conductive layer is patterned to form bottom electrode strips on the surface of the substrate to serve as the bottom electrodes of the LED pixels. The active regions comprise portions of the bottom electrode strips on which LED pixels are formed. The portions of the exposed substrate surface which, when viewed from the top, would not be occupied

by the second electrode strips of the LED pixels are, for example, the non-active regions.

Referring to Fig. 2c, a spacer layer 231 is deposited on the surface of the substrate. The spacer layer provides the material to form the cap support. The thickness of the spacer layer is equal to about the height of the cap support. In one embodiment, the thickness of the spacer layer is greater than a height of the subsequently formed active components to create a cavity between the active component and the cap. This protects the active components from being damaged by the cap. Typically, the height of the cavity is about 1-10 um.

In one embodiment, the spacer layer comprises a dielectric material to electrically isolate the active regions. The spacer layer can comprise directly or indirectly patternable materials. Preferably, the spacer layer comprises a photopatternable or photosensitive material that can be directly patterned. Photopatternable materials include, for example, photosensitive polyimide, photosensitive polybenzoxazole, photoresists, photoresists based on novolac systems, and dry film resist materials. Photoresists based on novolac systems are paticularly

useful since they can be cured and crosslinked to provide improved mechanical integrity over other types of non-curable resists. Indirect patternable materials include, for example, spin-on glass materials, polyimide, polybenzoxazole, polyglutarimide, benzocyclobutene, polymers such as polyethylene (PE), polystyrene (PS), polypropylene (PP), or inorganic materials such as SiO_2, Si_3N_4, and AL_2O_3.

Alternatively, the spacer layer can comprise a multi-layer architecture. For multi-layer spacer architectures, the lower portion comprises dielectric characteristics for isolating the anode electrodes of the LED pixels. If isolation is not necessary, the lower portion need not comprise dielectric characteristics. The upper portion can comprise various materials such as a metal. The use of a multi-layer spacer architecture can be advantageous since the upper portion can be selected to comprise a material that enhances sealing with a cap or encapsulation layer. For example, metals like Al, W, Ni, Cr, Co, Ag, Pt are useful as they facilitate good adhesion with a metallic cap. Polymers, such as PE, PP, PS, can be used to form the upper portion to provide good adhesion facilitate with a polymeric, a glass, or a metallic cap. The upper

and lower portions can include one or more layers. The total thickness of the layers is equal to about the desired height of the support posts.

The surface of the spacer layer may be planarized by, for example, chemical mechanical polishing (CMP) for subsequent processing. Providing a planar surface may be useful, particularly for devices having small features such as below 0.25 um.

Referring to Fig. 2d, the spacer layer is patterned to form the cap support 130 in the non-active regions 120 and the periphery of the device. Since the support posts are formed in the non-active regions, they do not interfere with the functionality of the active components.

Active components 110 are formed in the active regions 115. In one embodiment, organic LED pixels are formed in the active regions. Formation of the organic LED pixels includes, for example, depositing one or more organic layers 114 on the substrate. The organic layers comprise, for example, conjugated polymer or Alq_3. Other types of organic layers can also be useful. The thickness of the organic layers is typically about 2 - 200 nm.

The organic layers cover the bottom electrode strips as well as the support posts. The portions of the organic layers covering the support posts can be removed if necessary. Selective removal of the organic layers can be achieved using, for example, polishing. Other techniques for selective removal of the organic layers, such as etching, scratching, or laser ablation, can also be used.

Top electrode strips are then deposited on the substrate. The top electrode strips comprise a conductive material such as, for example, Ca, Mg, Ba, Ag or a mixture there of. Other conductive materials which comprises a low work function can also be useful. The top electrode strips are typically orthogonal to the bottom electrode strips. Forming top electrode strips that are diagonal to the bottom electrode strips is also useful. Selective deposition can be used to form the top electrode strips. Alternatively, the electrode strip can be formed by selectively patterning a top electrode layer to form the strips. The intersections of the top and bottom electrode strips form organic LED pixels.

Referring to Fig. 2e, a cap 180 is mounted on the cap support to encapsulate the device. The cap layer

comprises, for example, a metal or glass. Other types of cap which protect the active components from the environment, such as ceramic or metallized foil, are also useful. The cap is mounted onto the support post. Various techniques can be used to mount the cap layer. In one embodiment, an adhesive is used to mount the cap layer. Adhesives such as self-hardening adhesives, UV or thermal curable adhesives, or hot melt adhesives are useful. Other techniques which employ low temperature solder materials, ultrasonic bonding, or welding techniques using inductance or laser welding are also useful.

Figs. 3a-b show an alternative process for fabricating a device. Referring to Fig. 3a, a substrate 101 comprising active components 110 formed on its surface is provided. The active components, in one embodiment, comprise organic LED pixels to form a pixelated device. The organic LED pixels are formed in the active regions 115. As shown, the organic LED pixels comprises first and second electrodes 112 and 116 separated by at least one organic layer 114.

Referring to Fig. 3b, a spacer layer is deposited on the substrate to cover the active components and non-active regions. The spacer layer is patterned to form a

cap support 130 in the non-active regions 120 and in the periphery of the device. A cap 180 is mounted thereon to encapsulate the device, as described in Fig. 2e.

Figs. 4a-b show yet another process for forming the electrical device. Referring to Fig. 4a, a substrate 101 is provided with active components 110 formed thereon. In one embodiment, the active components comprise organic LED pixels of a pixelated LED device. The active components are formed over the active regions 115 of the substrate. The active components are separated by non-active regions 120.

A cap 490 is provided for encapsulating the device. The cap comprises a cap layer 180 with a cap support 130. The pattern of the cap support coincides with the non-active regions and the periphery of the device to surround the active components. In one embodiment, the cap is formed by depositing a spacer layer on the cap layer and selectively patterning it to form the cap support. The cap support can be formed with support posts having different height to accommodate features such as the pad 190, if necessary.

Referring to Fig. 4b, the cap is mounted onto the substrate, encapsulating the electrical device. Various techniques, such as those already described, can be used

to mount the cap. The cap protects the active components from the environment, such as air and/or moisture.

While the invention has been particularly shown and described with reference to various embodiments, it will be recognized by those skilled in the art that modifications and changes may be made to the present invention without departing from the spirit and scope thereof. The scope of the invention should therefore be determined not with reference to the above description but with reference to the appended claims along with their full scope of equivalents.

What is claimed is:

1. A device comprising:

a substrate having active and non-active regions;

an active component in the active region;

a cap support in a periphery of the device and in the non-active region;

a cap on the cap support; and

a cavity between the active component and the cap.

2. The device of claim 1 wherein the device comprises an organic LED (OLED) device which includes OLED pixels as the active component.

3. The device of claim 2 wherein the device comprises a flexible device.

4. The device of claim 3 wherein the cap comprises a flexible cap which encapsulates the device to hermetically seal the active component.

5. The device of claim 4 wherein the cap comprises a material selected from the group consisting of glass, metal, ceramic, or metallized foil.

6. The device of claim 5 wherein the substrate comprises a flexible substrate which provides mechanical integrity to support the active component.

7. The device of claim wherein 6 the flexible substrate comprises plastic, glass, or semiconductor material.

8. The device of claim 7 wherein the substrate comprises a thickness of about 20 - 300 um.

9. The device of claim 4 wherein the substrate comprises a flexible substrate which provides mechanical integrity to support the active component.

10. The device of claim 2 wherein the cap encapsulates the device to hermetically seal the active component.

11. The device of claim 10 wherein the substrate provides mechanical integrity to support the active component.

12. The device of claim 3 wherein the cap encapsulates the device to hermetically seal the active component.

13. The device of claim 12 wherein the substrate provides mechanical integrity to support the active component.

14. The device of claim 1 wherein the device comprises a flexible device.

15. The device of claim 14 wherein the cap comprises a flexible cap which encapsulates the device to hermetically seal the active component.

16. The device of claim 15 wherein the substrate comprises a flexible substrate which provides mechanical integrity to support the active component.

17. The device of claim 1 wherein the cap encapsulates the device to hermetically seal the active component.

18. The device of claim 17 wherein the substrate provides mechanical integrity to support the active component.

19. The device of claim 1 wherein the substrate provides mechanical integrity to support the active component.

20. The device of claim 1, 2, 3, 6, 7, 9, 11, 13, 14, 16, 17, or 19 wherein the cap support comprises a thickness greater than a height of the active component to form the cavity between the cover and the active component to prevent the cover from contacting the active component.

21. The device of claim 20 wherein the thickness of the cap support produces a cavity height of about 1 - 10 um.

22. The device of claim 21 wherein the support posts comprises directly or indirectly photopatternable material.

23. The device of claim 22 wherein the directly photopatternable material is selected from a group consisting of photosensitive polyimide, photosensitive polybenzoxazole, photoresists, photoresists based on novolac systems, or dry film resist materials and the

indirectly photopatternable material is selected from the group consisting of spin-on glass, polyimide, polybenzoxazole, polyglutarimide, benzocyclobutene, polymers, polyethylene, polystyrene, polypropylene, inorganic materials, SiO_2, Si_3N_4, or AL_2O_3.

24. The device of claim 20 wherein the support posts comprises directly or indirectly photopatternable material.

25. The device of claim 24 wherein the directly photopatternable material is selected from a group consisting of photosensitive polyimide, photosensitive polybenzoxazole, photoresists, photoresists based on novolac systems, or dry film resist materials and the indirectly photopatternable material is selected from the group consisting of spin-on glass, polyimide, polybenzoxazole, polyglutarimide, benzocyclobutene, polymers, polyethylene, polystyrene, polypropylene, inorganic materials, SiO_2, Si_3N_4, or AL_2O_3.

26. The device of claim 20 wherein the cap support comprises a multi-layer architecture having at least first and second support layers.

27. The device of claim 26 wherein the first layer comprises a dielectric material to provide electrical isolation for the active component.

28. The device of claim 27 wherein the first and second support layers comprise directly or indirectly photopatternable material.

29. The device of claim 26 wherein the first and second support layers comprise directly or indirectly photopatternable material.

30. A method for fabricating a device comprising:

providing a substrate;

defining active and non-active regions on the substrate;

encapsulating the device with a cap supported by a cap support, the cap support located in the non-active region and in a periphery of the device.

31. The method of claim 30 wherein the device comprises an organic LED (OLED) which includes OLED pixels as the active component.

32. The method of claim 31 wherein the OLED device comprises a flexible OLED device.

33. The method of claim 30 wherein the device comprises a flexible device.

34. The method of claim 30, 31, 32, or 33 wherein the cap includes the cap support.

35. The method of claim 34 wherein the cap support produces a cavity between the active component and the cap which prevents the cap from contacting the active component.

36. The method of claim 35 wherein encapsulating the device hermetically seals the active component.

37. The method of claim 31 or 32 further comprises forming the cap support.

38. The method of claim 37 wherein forming the cap support comprises:

forming a spacer layer over the substrate; and

patterning the spacer layer to form the cap support.

39. The method of claim 38 further comprises forming the active component in the active region prior to or after forming the cap support.

40. The method of claim 39 wherein forming the active component comprises:

forming a first electrode layer on the substrate;

patterning the first electrode layer to form first electrodes;

forming at least one organic layer over the electrodes;

forming a second electrode layer over the organic layer; and

patterning the second electrode layer to form second electrodes over the organic layer.

41. The method of claim 40 wherein encapsulating the device comprises mounting the cap on the cap support to hermetically seal the device.

42. The method of claim 37 further comprises forming the active component in the active region prior to or after forming the cap support.

43. The method of claim 42 wherein encapsulating the device comprises mounting the cap on the cap support to hermetically seal the device.

44. The method of claim 31 or 32 further comprises:

forming a first electrode layer over the substrate;

patterning the first electrode layer to form first electrodes of the OLED pixels.

45. The method of claim 44 further includes forming the cap support comprising:

forming a spacer layer over the substrate and first electrodes; and

patterning the spacer layer to form the cap support.

46. The method of claim 45 further comprises forming the active component in the active region prior to or after forming the cap support.

47. The method of claim 46 wherein forming the active component comprises:

forming at least one organic layer over the first electrodes;

forming a second electrode layer over the organic layer; and

patterning the second electrode layer to form second electrodes over the organic layer.

48. The method of claim 47 wherein encapsulating the device comprises mounting the cap on the cap support to hermetically seal the device.

49. The method of claim 45 wherein encapsulating the device comprises mounting the cap on the cap support to hermetically seal the device.

50. The method of claim 46 wherein encapsulating the device comprises mounting the cap on the cap support to hermetically seal the device.

51. The method of claim 30 or 33 further comprises forming the cap support.

52. The method of claim 51 wherein forming the cap support comprises:

forming a spacer layer over the substrate; and

patterning the spacer layer to form the cap support.

53. The method of claim 52 further comprises forming the active component in the active region prior to or after forming the cap support.

54. The method of claim 53 wherein encapsulating the device comprises mounting the cap on the cap support to hermetically seal the device.

55. The method of claim 51 further comprises forming the active component in the active region prior to or after forming the cap support.

56. The method of claim 55 wherein encapsulating the device comprises mounting the cap on the cap support to hermetically seal the device.

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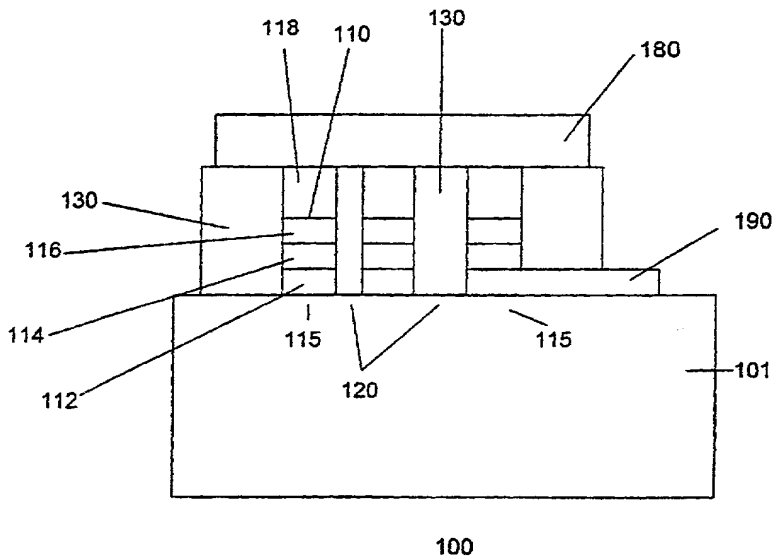
[Continued on next page]

(54) Title: ENCAPSULATION OF A DEVICE



(57) Abstract: An encapsulation for an electrical device (100) is disclosed. A cap support (130) is provided in the non-active regions (120) of the device (100) to prevent the package from contacting the active components (110) of the device due to mechanical stress induced in the package.

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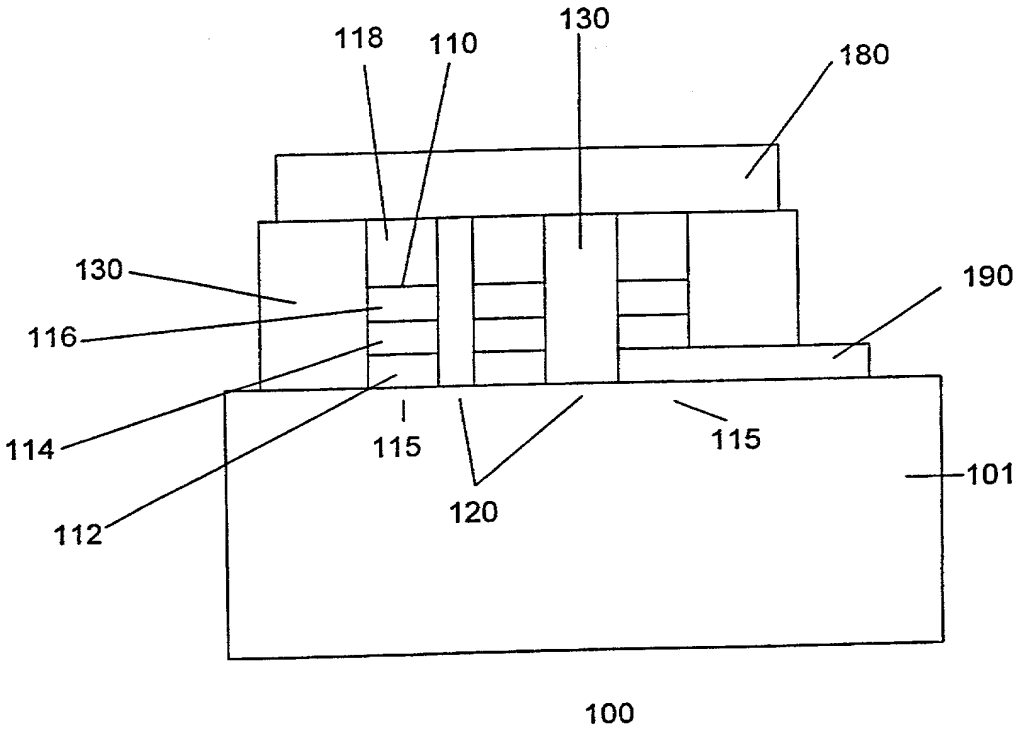


Fig. 1

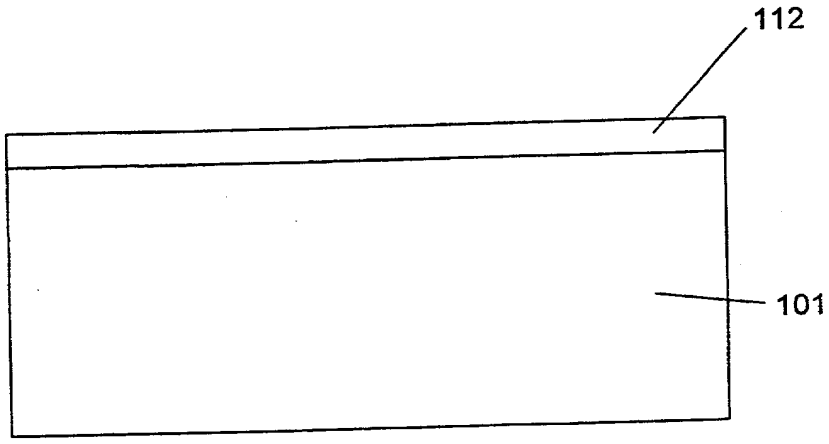


Fig. 2a

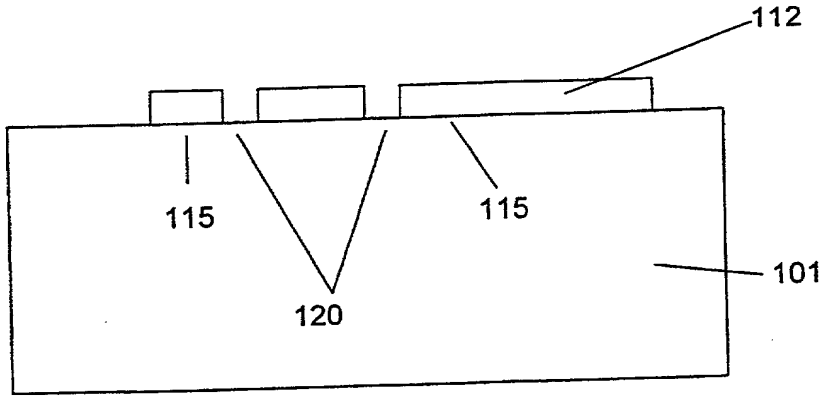


Fig. 2b

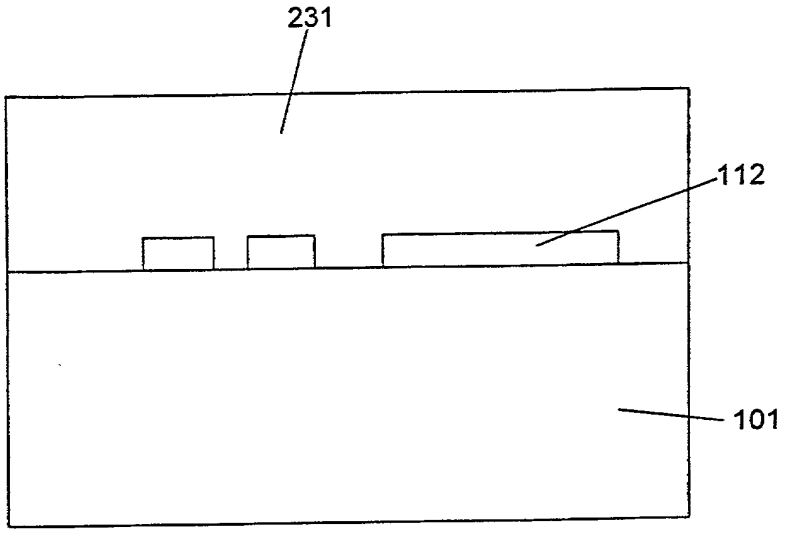


Fig. 2c

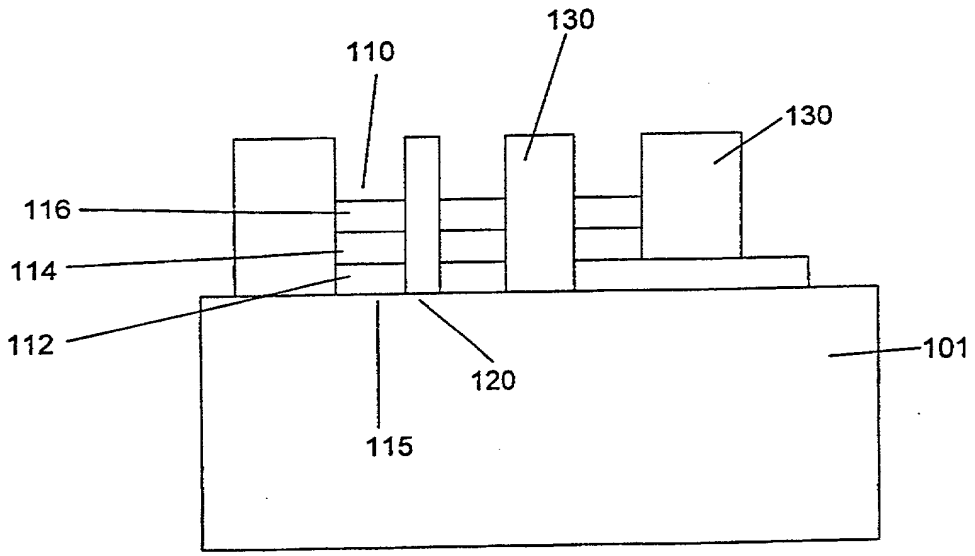


Fig. 2d

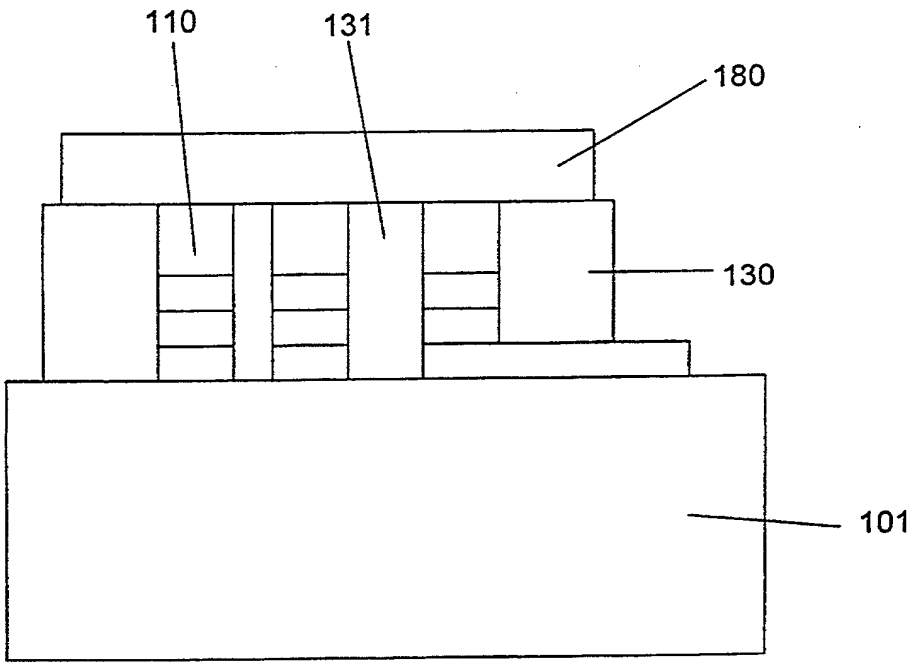


Fig. 2e

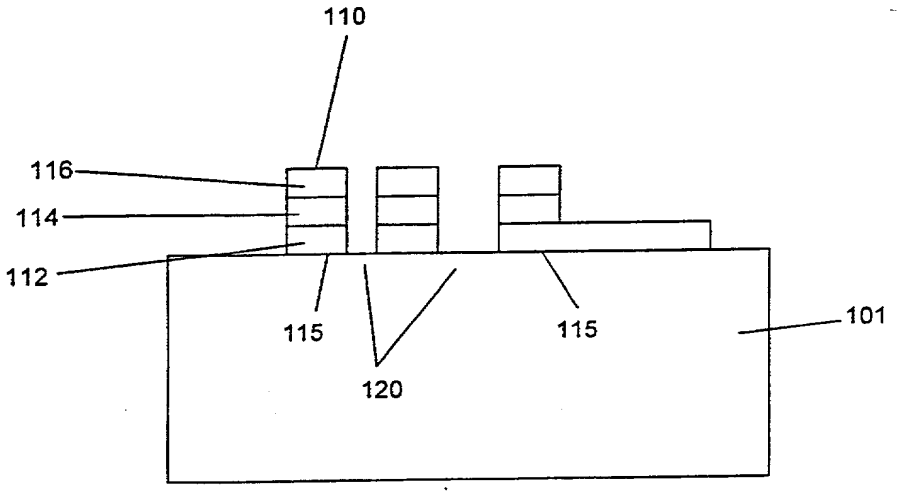


Fig. 3a

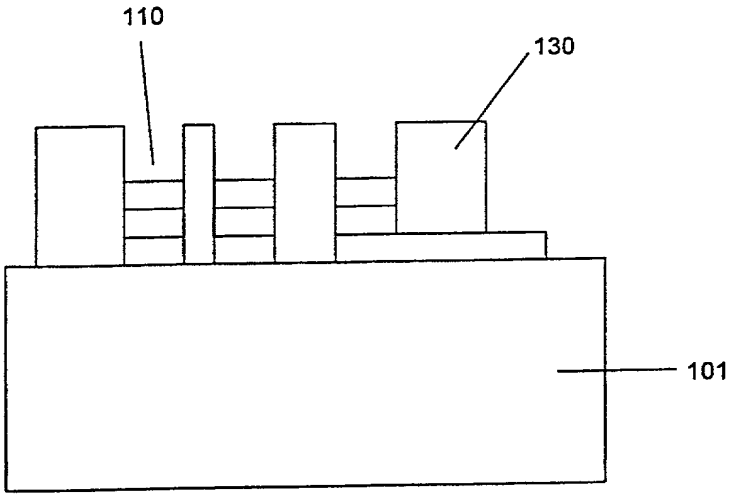
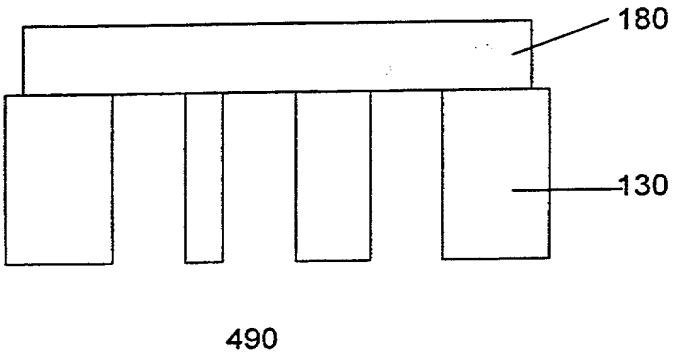


Fig. 3b



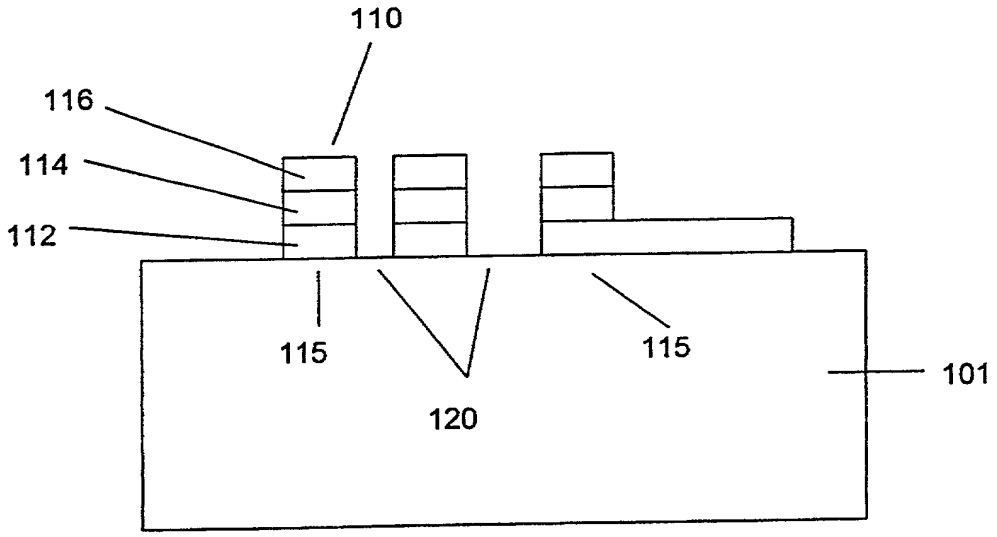


Fig. 4a

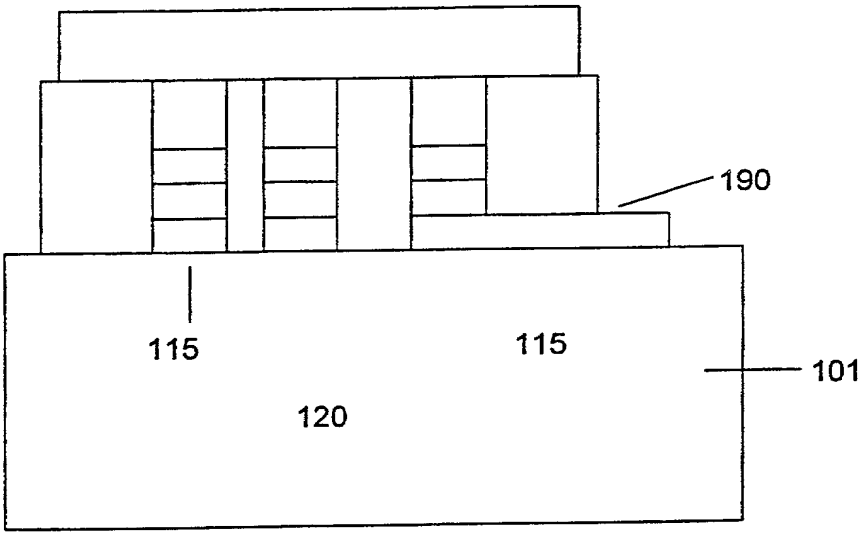


Fig. 4b

COMBINED DECLARATION AND POWER OF ATTORNEY

#4

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled ENCAPSULATION OF A DEVICE the specification of which:

- [] is attached hereto.
- [X] was filed as Application Serial No. 09/787,400.
- [X] was described and claimed in PCT International Application No. PCT/SG 99/00073 filed on July 9, 1999.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim the benefit under Title 35, United States Code, §119(e)(1) of any United States provisional application(s) listed below:

U.S. Serial No.	Filing Date	Status

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose all information I know to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT International filing date of this application:

U.S. Serial No.	Filing Date	Status

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

Country	Application No.	Filing Date	Priority Claimed
PCT	PCT/SG 99 00073	7/9/99	[X] Yes [] No

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

1-00

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